C-2.4 Compare the nuclear reactions of fission and fusion to chemical reactions (including the parts of the atom involved and the relative amounts of energy released).

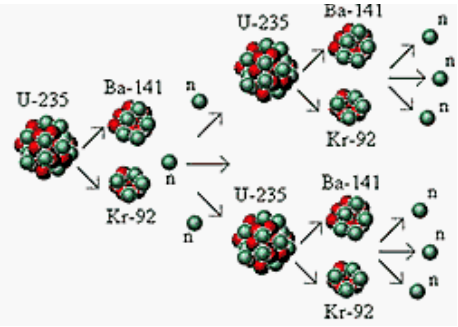
Revised Taxonomy Level 2.6 <u>Compare</u> conceptual knowledge

In Physical Science students:

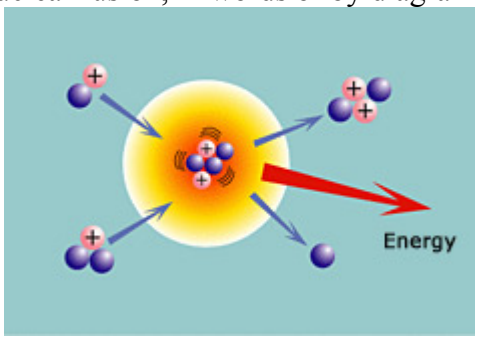
- Compare fission to fusion (including the basic processes and the fact that both fission and fusion convert a fraction of the mass of interacting particles into energy and release a great amount of energy. (PS-2.6)

It is essential for the students to

- Understand that chemical reactions occur in the electron clouds of atoms and nuclear reactions involve the nuclei of atoms.
- Illustrate the process of nuclear fission either in words or with a diagram



- Understand that there are several possible reactions that may occur during a fission reaction.
- Illustrate the process of nuclear fusion, in words or by diagram



- Understand that there are many possible reactions that may occur during a fusion reaction.
- Understand the source of energy from a nuclear reaction in terms of the nuclear mass equivalent, (mass defect) and Einstein's equation, $E = mc^2$
  - For energy release in fusion or fission, the products need to have a higher binding energy per nucleon (proton or neutron) than the reactants.
- Understand that the energy that results from a chemical reaction is the energy associated with chemical bonds (involving the electrons of the atom).
- Differentiate the energy from fusion reactions, fission reactions, and chemical reactions in terms of
  - Fuel

- Reaction Temperature
- Energy released per kg of fuel
- Energy-Releasing Reactions
- Region of the atom involved in the reaction

	Chemical	Fission	Fusion
Sample Reaction	$C + O_2 \rightarrow CO_2$	n + U-235 -> Ba-143 + Kr-91 + 2 n	H-2 + H-3 -> He-4 + n
Typical Inputs (to Power Plant) (Fuel)	Bituminous Coal	UO_2 (3% U-235 + 97% U-238)	Deuterium & Lithium
Typical Reaction Temperature (K)	700 K	1000 K	10^8 K
Energy Released per kg of Fuel (J/kg)	3.3×10^7 J/kg	2.1×10^{12} J/kg	3.4×10^{14} J/kg

Traditional Chemistry Differentiation

- Write and balance equations for a fission reactions (for example)
  - $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3\,{}^{1}_{0}n$
  - $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$
  - $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{137}_{52}Te + {}^{97}_{40}Zr + 2\,{}^{1}_{0}n$
  - Etc.
- Write and balance equations for a fusion reactions (for example)
  - $2\,{}^{1}_{1}H \rightarrow {}^{2}_{1}H + {}^{0}_{-1}e$
  - ${}^{1}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He + \gamma$
  - $2\,{}^{2}_{1}H \rightarrow {}^{3}_{1}H + {}^{1}_{1}H$
  - $2\,{}^{3}_{2}He \rightarrow {}^{4}_{2}He + 2\,{}^{1}_{1}H$
  - Etc.

Assessment

As stated in the indicator, the major focus of assessment is to compare (detect correspondences) in the nuclear reactions of fission and fusion to chemical reactions. Because the indicator is written as conceptual knowledge, assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together." In this case, assessments must show that students understand the processes in terms of the differences in the parts of the atom involved and the relative energy released.